Realising Energy Storage Technologies in Low-carbon Energy Systems (RESTLESS)

Paul Dodds (UCL) and the RESTLESS team

EPSRC
Pioneering research and skills

ENERGY SUPERSTORE
THE UK'S ENERGY STORAGE RESEARCH HUB

UKERC
UK Energy Research Centre

Collaborators

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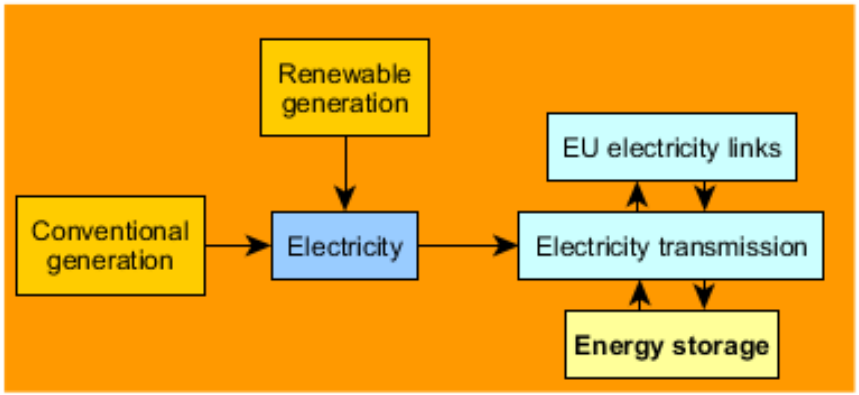
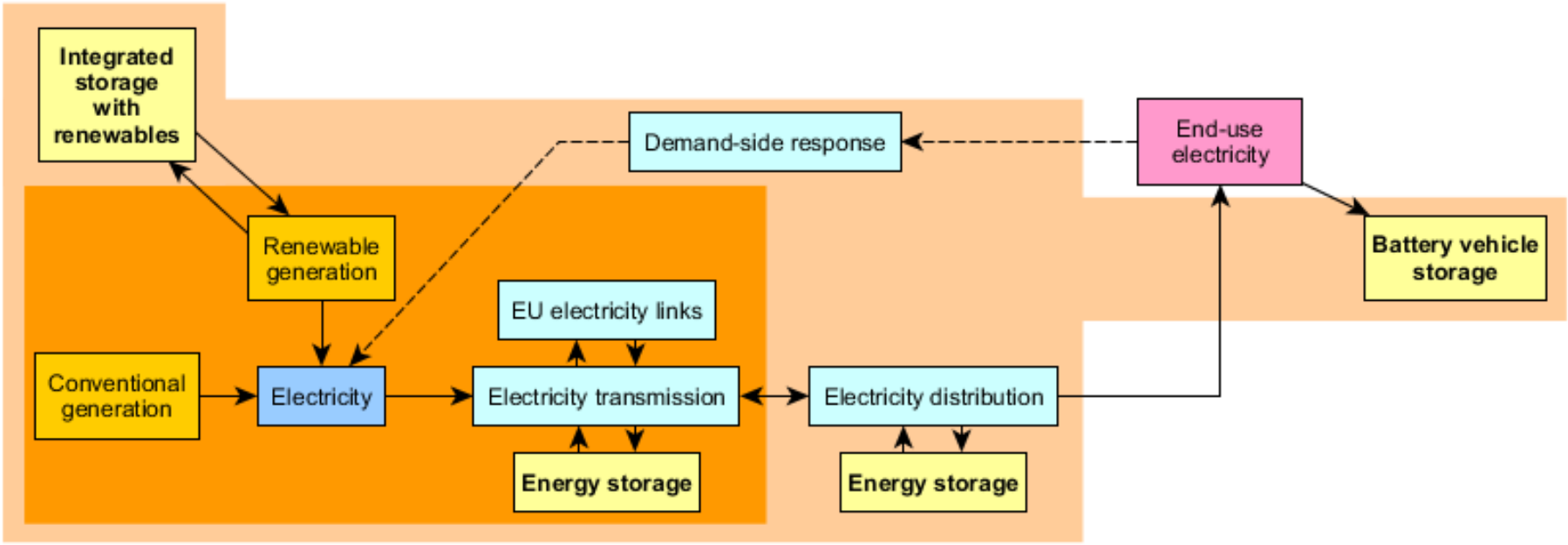
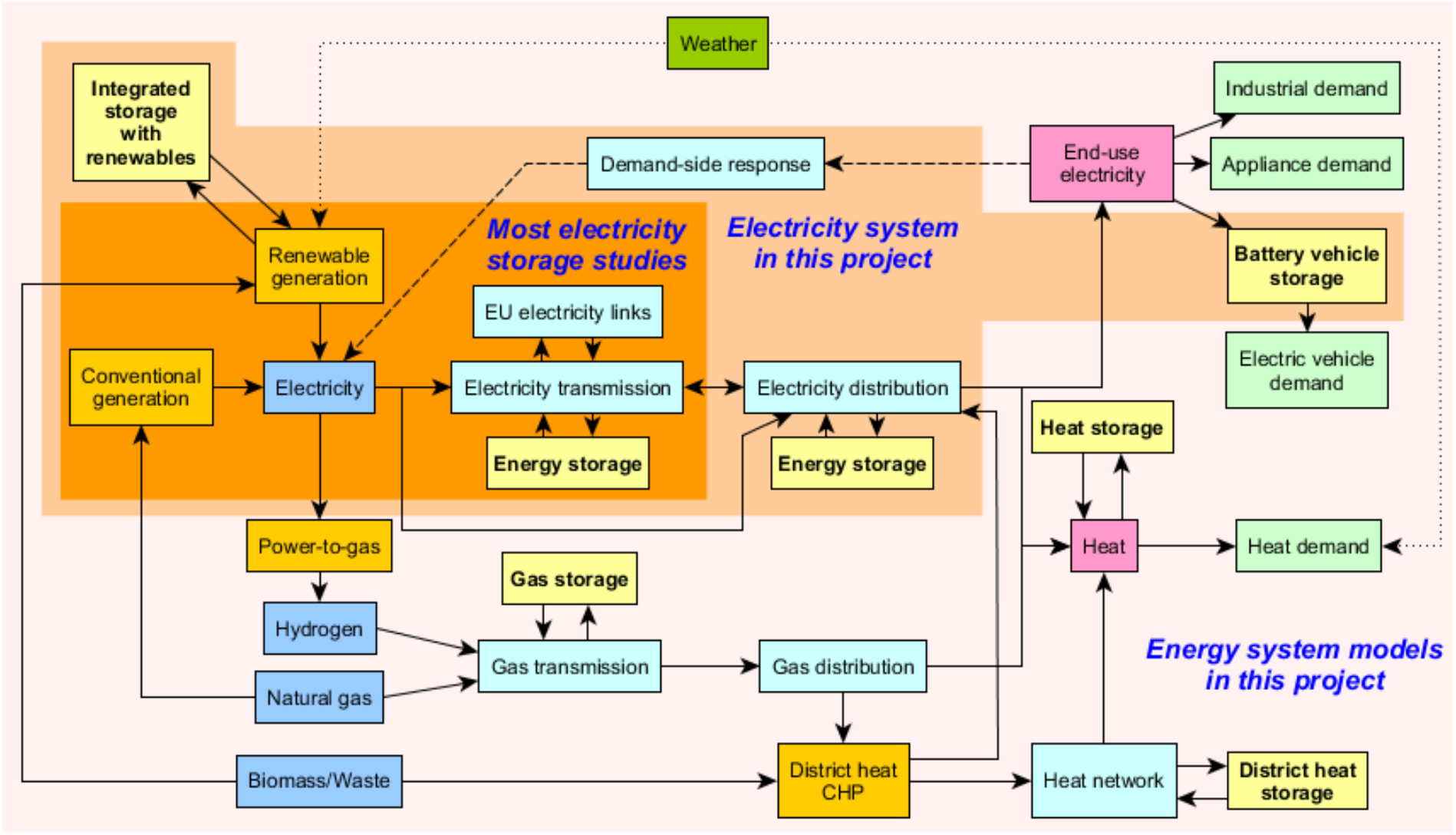
- Seamus Garvey, Jon McKechnie – Nottingham
- Keith Bell – Strathclyde
- Gareth Harrison, Harry van der Weijde – Edinburgh
- Nick Pidgeon – Cardiff
- Jonathan Radcliffe – Birmingham

Aim

To understand how novel ES technologies might be integrated into the UK energy system in the future


Renewable generation
EU electricity links
Conventional generation
Electricity
Electricity transmission
Energy storage


Integrated storage with renewables
Demand-side response
End-use electricity
Renewable generation
Battery vehicle storage
EU electricity links
Conventional generation
Electricity
Electricity transmission
Electricity distribution
Energy storage
Energy storage


Weather
Integrated storage with renewables
Industrial demand
Demand-side response
End-use electricity
Appliance demand
Most electricity storage studies
Electricity system in this project
Renewable generation
Battery vehicle storage
EU electricity links
Electric vehicle demand
Conventional generation
Electricity
Electricity transmission
Electricity distribution
Heat storage
Energy storage
Energy storage
Power-to-gas
Heat
Heat demand
Gas storage
Hydrogen
Gas transmission
Gas distribution
Energy system models in this project
Natural gas
Biomass/Waste
District heat CHP
Heat network
District heat storage

Storage technologies

MECHANICAL / THERMOMECHANICAL/ GRAVITATIONAL

- Pumped Hydro
- Heat Pumped Temperature Difference System
- Liquid Air Energy Storage (LAES)
- Compressed Air Energy Storage (CAES)
- CAES Undersea Bags
- Pumped Hydro with Compressed Air
- Flywheels
- Advance Rail Energy Storage

ELECTRO-CHEMICAL

- Rechargeable Batteries (e.g. Lead–acid, Lithium–ion, Sodium–sulfur)
- Vanadium Redox Flow Batteries
- Supercapacitors

THERMAL

- Phase Changes
- Solar Ponds
- Sensible Thermal Energy Storage: Diurnal and Seasonal

CHEMICAL

- Hydrogen from Water Electrolysis
- Chemical Reactions (zeolites/water/ inorganic oxides)
- Power to Gas
- Large Scale Hydrogen Storage
- Traditional Energy Storage (natural gas, oil and coal)

OTHER

- Superconducting Magnetic Energy Storage

Comparing technologies

- Specific (output) energy (J/kg)
- Output energy density (J/m3)
- Specific power (W/kg) (o/p & i/p)
- Power density (W/m3) (o/p & i/p)
- Minimum natural energy & power scales of a single device (J & W)
- Optimum natural energy & power scales of a single device (J & W)
- Nominal cost per unit energy & power at optimum scale (£/J & £/W)
- Marginal cost per unit energy & power at optimum scale (£/J & £/W)
- Lowest power slew rate at which performance degrades noticeably (W/s)
- Effective turnaround efficiency
- etc…

Analysing the future role for energy storage

Grid-scale electricity models	Energy system models
Only the electrical system Fixed electricity demand	Whole energy system Flexible electricity demand
Only grid-scale storage	All types of energy storage
High temporal resolution 30 mins/1 hour	Low temporal resolution 4 daily periods, 4 seasons
Several studies	No studies

Understanding the value and potential roles of storage

	Energy system model	Electricity system model
European-scale: interconnectors	European TIMES Model (UCL) ⟷	ANTARES (Strathclyde)
	Boundary conditions ↓	
UK transmission-scale	UK TIMES Model, DynEMo (UCL) ⟷	Dispatch/network model (Edinburgh)
	Boundary conditions ↓	
UK distribution-scale	New energy system model? (UCL) ⟷	IPSA urban models (Strathclyde)

Distribution-scale models to be jointly developed with the UK Energy Research Centre

Economics (UCL)

- Understand how the value of ES technologies can be realised through the design of electricity markets and business models.
  - Role of electricity storage in OECD markets
  - Realising the value of energy storage for consumers
  - Economic models for encouraging ES technologies

Electricity market issues

Regulatory Challenges to Energy Storage Deployment

An Overview of the UK Market

Realising Energy Storage Technologies in Low-carbon Energy Systems

Working Paper 1

Giorgio Castagneto-Gissey and Paul E. Dodds

UCL Energy Institute

April 2016

RESTLESS

Realising Energy Storage Technologies in Low-carbon Energy Systems
An EPSRC-funded project

Regulatory barriers to energy storage deployment: the UK perspective

Giorgio Castagneto Gissey, Paul E. Dodds *UCL Energy Institute*
Jonathan Radcliffe *Birmingham Energy Institute*

Energy storage could make an important contribution to balancing a low-carbon energy system in the future for the UK, and the technologies have high export potential. A rapidly-growing family of technologies that can meet multiple system needs are in development. Innovation is required to reduce the costs of storage technologies, but their widespread deployment into electricity markets that is required to underpin this innovation is not occurring.

This briefing paper examines the regulatory barriers that power-to-power energy storage technologies are facing in the UK and in other major international markets. We consider that the creation of a new regulatory definition would facilitate the removal of barriers to the deployment of storage. Allowing transmission and distribution network operators to own and operate storage would enable its role in the system to be optimised, as long as competition concerns could be satisfied. However, some direct support for small-scale investments might still be necessary, perhaps using a similar approach to California. Many countries are facing the same challenge and initiatives to encourage deployment of energy storage are underway in Germany, Italy, Belgium and the United States. The value from investment in UK research efforts could be lost without similar action.

Contents

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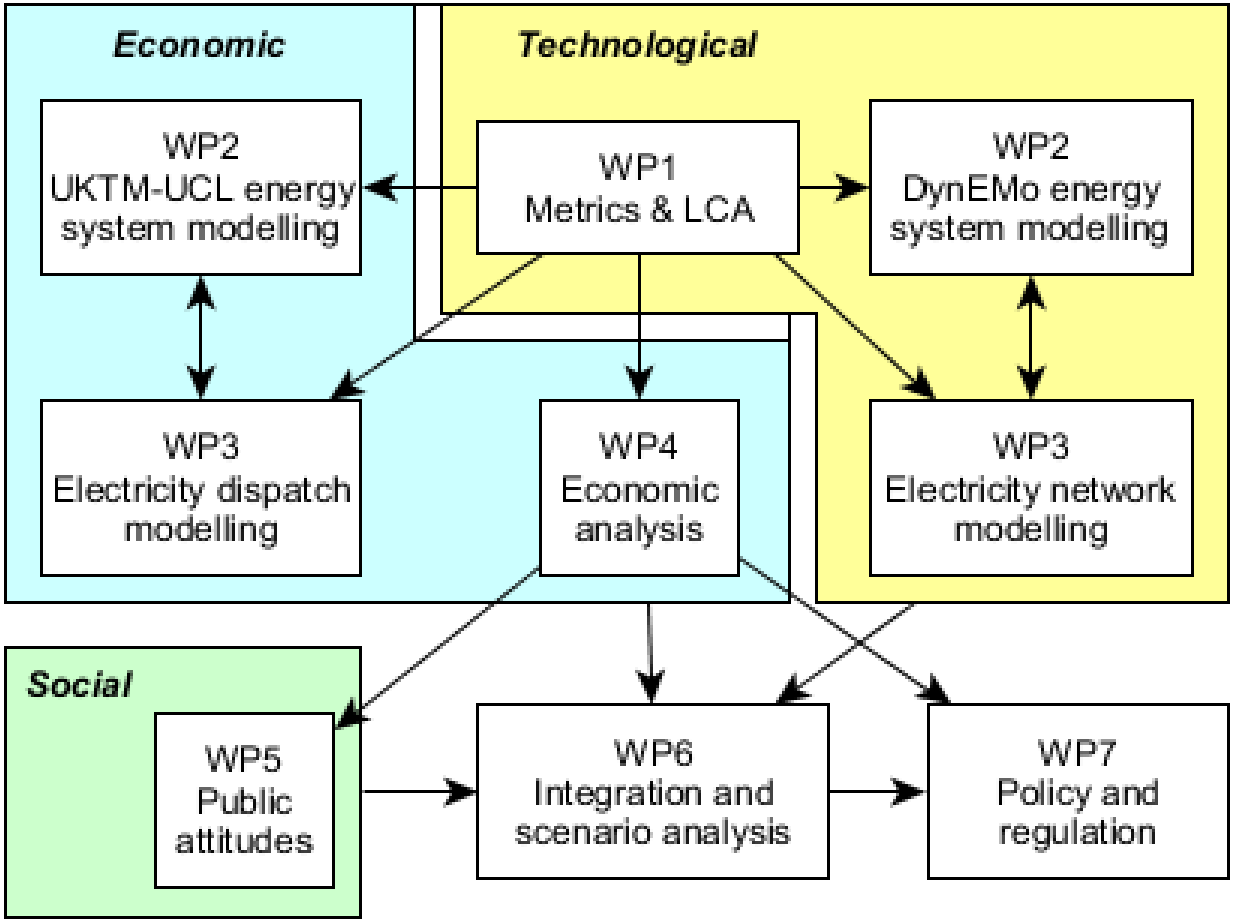
Public acceptance (Cardiff)

- Public attitudes towards ES technologies and the roles that they might have in the future UK energy system
  - Builds on UKERC II research
  - Responsible Research and Innovation (RRI) framework
  - Four deliberative workshops across the UK

Policy and regulation (Birmingham)

- Policy implications
- Stakeholder engagement
- National Roadmap for Energy Storage
  - Building on roadmap currently being produced by the Supergen “Superstore” Hub


Economic
Technological
WP2
UKTM-UCL energy system modelling
WP1
Metrics & LCA
WP2
DynEMo energy system modelling
WP3
Electricity dispatch modelling
WP4
Economic analysis
WP3
Electricity network modelling
Social
WP5
Public attitudes
WP6
Integration and scenario analysis
WP7
Policy and regulation

Project overview

- Started in September 2015
- 4-year project